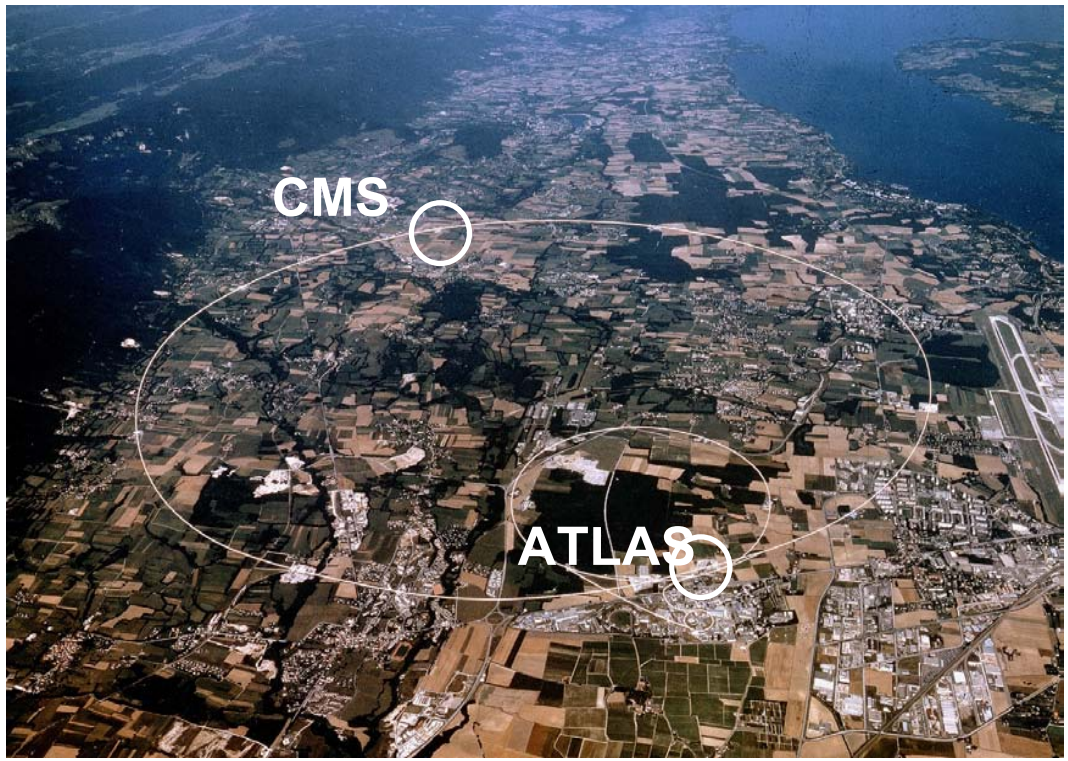
HCAL Constants

Shuichi Kunori
U of Maryland
21-July-2003

LHC and CMS
HCAL plan
Four Databases

Caution - All information in these slides are very preliminary and some may be wrong.

The LHC

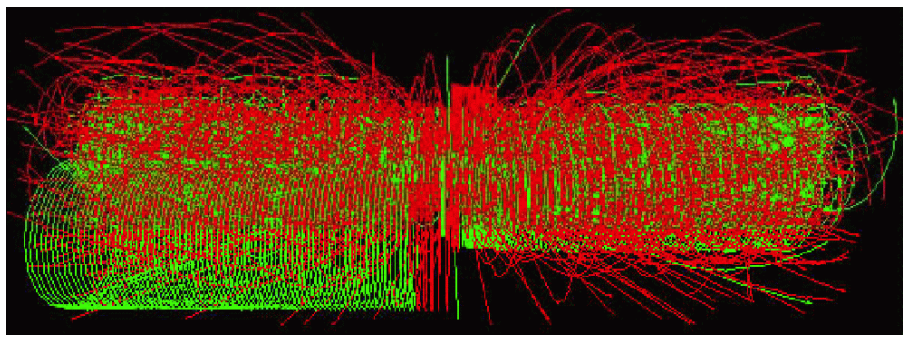


R = 4.5 Km
E = 7+7 TeV (pp)

crossing rate
=40MHz
(25nsec)

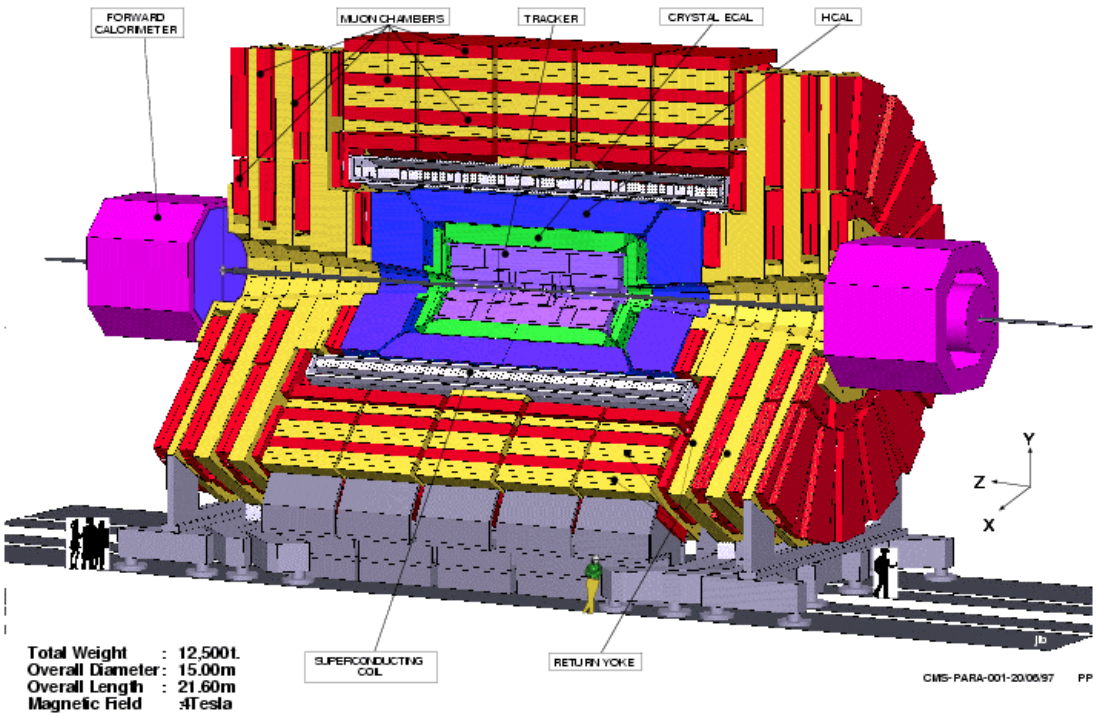
design luminosity
= $10^{34}cm^{-2}s^{-1}$

~20 pp interactions
per crossing
at design luminosity



h → 4 μ with 20 min. bias evt.

The CMS detector



Toal weight	12500 t
Overall diameter	15 m
Overall length	21.6 m

All silicon tracker
- micro strips (10M ch)
- pixel (40M ch)

(5.4m long, 2.4m Φ: |η| <2.4)

Hermetic calorimeter
- ECAL: PbWO4 crystal
- HCAL: brass+scinti.

(|η| <3.0)

in 4 Tesla solenoid

(12.5m long, 6m Φ in)

Robust muon system
- DT+RPC (barrel)
- CSC+RPC (endcap)

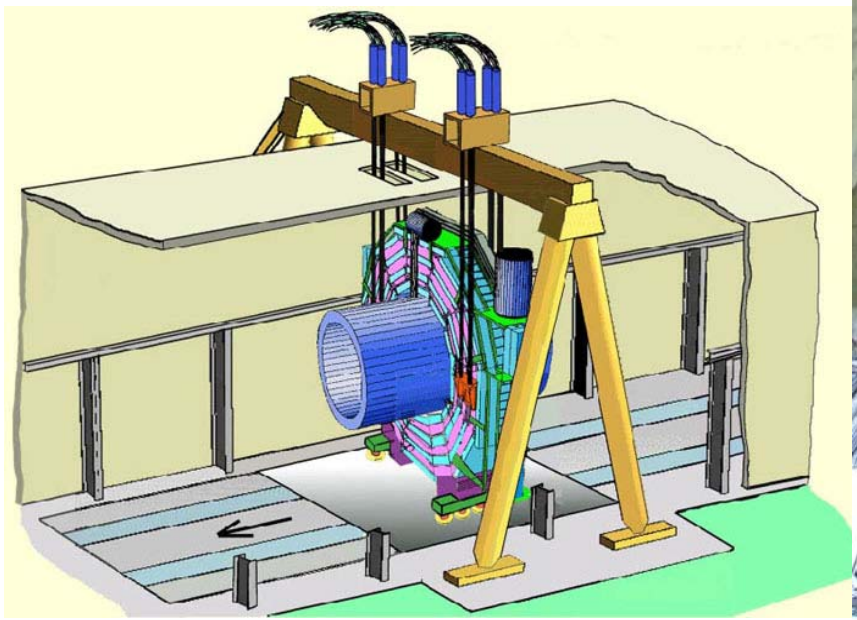
(in iron yoke: |η| <2.4)

Fast cerenkov calor.
- quartz fibber

(3<|η|<5)

Surface buildings and main shaft

Installation of the first muon chamber



Transfer YB0 (2000t) in 2005

HCAL plan

2003 June-September

- **Calibration runs in the H2 testbeam at CERN**
  - All HCAL subdetectors: HB, HE, HF, HO + Crystals

2004 Summer-

- **Low energy testbeam at H2**
  - EC+HC response to low energy beam
  - hadron showers at low energy
- **Slice test with EMU, TRIG and DAQ at CMS.**
  - Full system test - hardware & software & operation

2005

- **Transfer HCAL to the under-ground experimental hall.**

2006

- **Test beam (?)**
- **Integration and commissioning**

2007

- **Data taking**

Conditions Database

All information needed for event reconstruction (HLT/Offiline)

HB, HE, HO : scintillator/brass sampling calorimeter
scint. - HPD – QIE (ADC) – HTR (Trig Primitive/pipeline) – L1/DAQ
HF : quartz fiber/iron calorimeter
fibers - PMT – QIE (ADC) – HTR (Trig Primitive/pipeline) – L1/DAQ

Readout channels ~ 10k
Stable detector – no need to update constants frequently, hopefully.
HF gain will decrease due to radiation damage (slow time constant).

Constants – from ADC counts to GeV

1) Channel response (scint-HPD-QIE)	1	* 10k (ch)
2) QIE calibration (ADC-to-Charge(fC))	128 (bin)	* 10k (ch)
3) Charge-to-GeV (HB,HE,HO,HF)	1	* 4
4) Pedestal	4 (capid)	* 10k (ch)

+) Channel# – (eta,phi,depth) map

Configuration DB

All information required to bring the detector in any running mode.

Run modes:

1) beam, 2) pedestal 3) source calib 4) laser calib 5) LED calib

Constants (on detector)

HPD/PMT	- HV	1/(HPD or PMT)
CCM	- clock phase	1/(ch)
CalibModule	- mode+	

Constants (in counting room)

HTR	- pedestal	1/(ch)
	- LUT(ADC-to-GEV)	1LUT/(ch)
	- threshold	1/(ch)
TTC	- timing	

Integration Database

All information to physically set up the detector and is used for asset tracking

Detector components: (on detector)

- 1) Absorber
- 2a) Megatile
- 2b) Quartz fiber bundle (HF)
- 3) Optical cable
- 4) RBX(readout box)
- 4.1) RM{ODU, HPD(PMT), QIE}
- 4.2) CCM
- 4.3) Calibration Module
- 5) Cable
- +) shielding, support (HF)

Detector components: (in counting room)

- 1) Crate
- 1.1) HTR
- 1.2) TTC

Channel map (eta,phi,depth)→megatile→optical cable→RM{ODU,HPD,QIE}→HTR(ch)}

Construction/Hardware DB

C-DB: all information about the sub detector construction up to the start of integration.

H-DB: all information required for cross checking calibration constants and for detector simulation.

Detector components: (on detector)

1) Absorber	- dimension, source tube location (HF)
2a) Megatile/fibers	- dimension, fiber length, att.length, source scan
2b) Quartz fiber bundle (HF)	- type
3) Optical cable	- length
4) RBX(readout box)	-
4.1) RM{ODU, HPD(PMT), QIE}	- HPD(PMT) gain, QIE(ADC→fC, timing), map
4.2) CCM	-
4.3) Calibration Module	-
5) data cable	-
+) shielding, support (HF)	

Detector components: (in counting room)

- 1) Crate
- 1.1) HTR
- 1.2) TTC

Calibration Data

Additional slides

Data Flow

>>> front end <<<

Scint. Lights
->Tile->Fiber1&2->OptCable
->HPD->Amp->ADC->
Charge (for 5-10xings)
->(L1Path)
->(DAQPath)

>>> L1Path <<<

->HTR (ch)
E_T(L1Primitive: 8bits:non-linear)
->L1 LUT (ch)
E_T(4x4 HcTower: 8bits:linear)
->L1Calo
E_T(L1jets),Et(L1tau),Et(L1MET)
->L1CaloGlobal(Threshold (obj))
->L1Global
L1Trigger

>>> after DAQPath <<<

->ReadoutAnalyzer (ch)
E_T(channel)
->TowerCreator
E_T(Ec+Hc Tower)
->Jet/MET/tauReco
E_T(jetR),Et(tauR),Et(METR)
->EtCaloCorrection (obj)
(corr. for linearlity)
E_T(JetC),Et(tauC),Et(METC)
->EtPhysCorrection (obj)
(corr. for out-of-cone)
E_T(Parton)

Calibration/correction
(ch) - channel by channel
(obj) - phys. Obj, (jet, tau, MET)

Tools

A) Megatile scanner:
- Co^{60} gamma source
- each tile: light yield
- during construction
  - all tiles

B) Moving radio active source:
- Co^{60} gamma source
- full chain: gain
- during CMS-open (manual)
  - all tiles
- during off beam time (remote)
  - tiles in layer 0 & 9

C) UV Laser:
- full chain: timing, gain-change
- during off beam time
  - tiles in layer 0 & 9
  - all RBX

D) Blue LED:
- timing, gain change
- during the off beam time
  - all RBX

E) Test beam
- normalization between
  - GeV vs. ADC vs. A,B,C,D
- ratios: elec/pion, muon/pion
- before assembly
  - a few wedges

F) Physics events
- mip signal, link to HO
  - muon
- calo energy scale (e/pi)
  - charged hadron
- physics energy scale
  - Min-bias
  - photon+jet balancing
  - Z+jet balancing
  - jet-jet balancing
  - di-jet mass
    - W->jj in top decay

>> non-linear response

>> pile-up effect

Scenario (HB/HE)

(same to HF)

1) Before megatile insertion

- megatile scanner: all tiles
- moving wire source: all tiles

2.1) After megatile insertion

- moving wire source: all tiles / 2 layer
- UV laser: 2 layers/wedge

2.2) After megatile insertion

- test beam: a few wedges.

→ Absolute calib. Accuracy of 2% for single particle

3) Before closing the CMS

- moving wire source: all tiles
- UV laser & blue LED: all RBX

(do 3, about once/year)

4) Beam off times

- moving wire source: 2layer/wedge
- UV laser: 2 laer/wedge
- UV laser & blue LED: all RBX

→ Monitor for change with time Accuracy < 1%

5) Beam on (in situ)

- jets / tau / MET ECAL+HCAL

once/month

a few times/day (?)